ARMY RESEARCH LABORATORY

Correlation Analysis of VLSTRACK Model Results With Theoretical and Experimental Data for Rigid Sphere Terminal Velocities

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ARL-TR-1938

April 1999

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Abstract

In this report, we undertake the task of verifying the VLSTRACK model on the specific example of raindrop terminal velocities, which were calculated directly from Fluid Dynamics. In this example, the verification is in good agreement with experiments.

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Executive Summary

In this research, we undertook a task to verify the validity of the Vapor, Liquid, and Solid Tracking (VLSTRACK) Computer Model in calculating terminal velocity of raindrops. The findings compare very well with Fluid Dynamics calculations and experiments.

The version VLSTRACK 1.6.2, used here, is developed and owned by the U.S. Naval Surface Warfare Center (NSWC), Dahlgren Division, Dahlgren, VA 22448-5100.

If the revision of VLSTRACK is contemplated, we recommend that more detailed documentation of input parameters for explaining specific tasks be included.

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1. Introduction

In this report, we are verifying whether the VLSTRACK [1] computer model is applicable for a specific example—comparison of terminal velocities of falling water droplets under the influence of gravity and drag forces (the drag forces contain ordinary drag forces and buoyancy forces). Specifically, we are comparing the VLSTRACK calculated terminal velocities in the atmosphere with those calculated interactively through fluid dynamics formalism [2].

Although one might think that this is a simple task, it turned out that before one could set VLSTRACK to calculate the terminal velocities, a lot of preliminary manipulations were necessary in the data input files in order to successfully accomplish this comparison.

Section 2 outlines the purpose of this analysis. Section 3 is devoted to recapitulation of fluid dynamics calculations of raindrop terminal velocities and the experimentally determined values. The analysis using VLSTRACK is discussed in section 4. Section 5 provides the velocities and summarizes the results. The significant results are discussed in section 6.

The purpose of this report is to show that an accurate description of a particular situation by VLSTRACK requires significant manipulation of input VLSTRACK parameters. Our specific example of VLSTRACK calculated raindrop terminal velocities and their subsequent comparison with fluid dynamics calculations [2] and experimental data [3] illustrates how comparisons for other agents may be made.

2. Theory: Overview of Fluid Dynamics Calculations of Raindrop Terminal Velocities

Here we give a short review of fluid dynamics calculations of raindrop terminal velocities. A full account may be found in Soln [2].

When a raindrop is of a diameter that is smaller than 5 mm, one can treat a freely falling droplet as a sphere; a fact that can be verified a posteriori by comparison with experiments.

Treating a droplet as a sphere with water density simplifies the calculation of the terminal velocities.

For the sake of completeness, we write down the differential equation for the water sphere when forces acting on it are all in the vertical direction. The velocity of the sphere in the horizontal direction is assumed to be zero. Hence the differential equation for the vertical motion of the sphere reads as follows:

$$\frac{d^2y}{dt^2} = \left(1 + \frac{\bar{\rho}}{2}\right) \left[- (1 - \bar{\rho})\, g - \frac{3\bar{\rho}}{4d}\, c_d\, u\,|u| \right], \tag{1}$$

where u is the velocity of the sphere in the vertical direction, whose coordinate here is denoted as y, looking upward.

The relevant parameters appearing in equation (1) are:

$$\rho = 1000.0 \text{ kg/m}^3, \ \rho_f = 1.22 \text{ kg/m}^3, \ \bar{\rho} = \frac{\rho_f}{\rho} = 0.0012, \ g = 9.8 \text{ m/s}^2, \tag{2}$$

where ρ is the density of water, ρ_f is the density of air, and c_d is a drag coefficient that depends on the dimensionless Reynolds number

$$c_d = c_d\,(R_e)\,. \tag{3}$$

The Reynolds number has to be computed separately for each velocity, u, according to

$$R_e = \frac{ud}{\nu}, \tag{4}$$

where d is the diameter of the sphere and ν is the ordinary viscosity of air:

$$\nu = 0.0000149 \text{ m}^2/\text{s}\,. \tag{5}$$

For air as a medium, empirical relation (3) can be specified as [2, 3]

$$c_d = \frac{24}{R_e^{0.646}},\ 1 < R_e \leq 400. \tag{6}$$

The terminal velocity u_t follows when equation (1), acceleration, is equivalent to zero, i.e., when the velocity in the downward direction becomes constant. Thus, equating (1) to zero and setting $u = -u_t$, where u_t looks in the downward direction, we obtain:

$$u_t = \sqrt{\frac{4g(1-\bar{\rho})d}{c_d 3\bar{\rho}}}. \tag{7}$$

The next thing one does is to "guess" on the initial value of terminal velocity u_t for a droplet with a given diameter d. For example, for $d = 0.001$ m, we guess the initial value for u_t to be 3 m/s. Putting this into relation (4) for the velocity u, we obtain $R_e = 201.34$. This now is used to calculate c_d according to relation (6), resulting in $c_d = 0.78$. Now we have everything for calculating the "improved" value for u_t according to relation (7). The improved value is $u_t = 3.73$ m/s. Now one repeats the cycle with this new value for u_t yielding even better approximation for u_t. Eventually, this repetition will yield u_t's that do not differ from each other, which means that we found the most accurate value for u_t. In our case, $u_t = 4.1$ m/s as a final value.

One can do this type of calculation of u_t for every diameter d. The results are exhibited and compared to equivalent values and VLSTRACK calculations in Table 1.

Table 1. Comparison of VLSTRACK Calculated, Fluid Dynamics Calculated, and Experimental Terminal Velocities of Water Droplets

Mass Median Diameter (MMD) (μ)	Fluid Dynamics Calculations of Terminal Velocity of Water (Sphere) (m/min)	VLSTRACK Calculations of Terminal Velocity of Water (Sphere) (m/min)	Measured Terminal Velocity of Water (Droplet) (m/min)
500	108.0	122.8	120.0
1,000	246.0	232.9	240.0
1,500	336.0	305.6	330.0
2,000	390.0	379.8	396.0
2,500	444.0	407.5	450.0
3,000	480.0	431.6	492.0
3,500	522.0	448.2	522.0
4,000	558.0	453.8	540.0
4,500	588.0	458.8	546.0
5,000	624.0	463.3	546.0
5,500	648.0	467.4	552.0
6,000	684.0	471.2	552.0

The measured terminal velocities of water droplets come from Blanchard [3]. The VLSTRACK data will be discussed in the next section.

3. Implementation: Analysis Using VLSTRACK

Now that we have provided the rationale for calculated terminal velocity, we want to look at VLSTRACK computer model [1] calculated terminal velocities compared to those we have calculated interactively through the fluid dynamics equation sequence discussed in Section 2.

The sequence we used to set up the VLSTRACK files is discussed in this section. We are going to specify the process used to compute the VLSTRACK results in Table 1. Before starting to

interrogate VLSTRACK, we must determine the boundaries of what comparisons we want to make. We want to compare VLSTRACK calculated values to the fluid dynamics calculated values, so we need to duplicate the parameters used in the fluid dynamics terminal velocity calculations as closely as possible. This means that we want to look at the water droplet as a rigid sphere. We therefore set forth to define a VLSTRACK "threat" scenario that will replicate the physical conditions and properties of a rigid sphere of water and will mimic stabile atmospheric conditions.

The first step in this definition sequence was to establish an agent in the agent parameter file named VLSAGN.PAR [1] to define the physical properties of the rigid sphere of water. The agent file was modified to identify water as a biological type agent (type 5), meaning that the water would be treated as particle beads rather than as a liquid.

Agent parameter file specifications also include the bulk density, dissemination efficiency, median lethal or effective dosage, probit slope, and freezing temperature. Dissemination efficiency was set at 100%, and median lethal or effective dosage was set at only 0.001 mg-mi/m^3 to assure the water would exhibit deposition (in the case of deposition runs) and that effects would be detected (in the case of dosage effects runs). The bulk density, probit slope, and freezing temperature were set equivalent to that of water. In addition to the overall agent identification, each type 5 agent includes particle MMD [1], geometric droplet/particle distribution sigma, particle density, daytime biological decay rate, nighttime biological decay rate, biological agent purity, and biological agent dissemination efficiency for exploding munitions. The particle MMD was varied from 500 μ to 6,000 μ in increments of 500 μ. The fluid dynamics calculations are valid up to a water droplet diameter of 5,000 μ. We included up to 6,000 μ diameters in order to exhibit explicitly the departure from experimental values. The geometric droplet/particle distribution sigma was set at 1, signifying that all droplets are the same size; the particle density was set at that of water (at 21° C) equal to 1 g/cm^3; and the biological agent dissemination efficiency is not pertinent since it is not used when user-defined (i.e., puff-type, localized concentration of a gaseous or liquid substance [1]) munitions are utilized. Daytime and nighttime biological decay rates were set at zero, and the biological agent purity was set at 100% to maximize capacity of the water "hazard."

The second sequential step was to define a munition in the parameter file named VLSMUN.PAR [1], which is the location where munition descriptions are built or modified. It was decided to disseminate water in puffs as a line source to view the water from each puff as it was deposited via the graphics output file, to track and compare terminal velocities of each puff by reviewing the output files named VLSTRACK.TRK and VLSTRACK.REC, respectively [1]. The munition was categorized as a user defined munition and then further defined in a separate puff property file named VLSTRACK.POS [1]. This file was configured to contain five records for each munition puff, including the mass, downrange and crossrange distance, height, and detonation time. After making several successful VLSTRACK runs, in terms of measuring terminal velocity, a standard scenario was established and then the puff property file parameters were varied many times. Keeping in mind that it was desired to make the puff release height higher than the distance the droplet would travel in 1 min, the puff parameter values were varied to substantiate uniformity of terminal velocity from run to run and to determine terminal velocity for each different MMD.

The third step was to develop a meteorology file in a file named VLSTRACK.MET. We know that meteorological conditions have a significant impact on how agents transport and disperse on the battlefield. The object of our VLSTRACK.MET file is to define atmospheric conditions that parallel the constant conditions used for the fluid dynamics calculations [2] for the droplets under the influence of only gravity and drag. Preliminary VLSTRACK runs were performed using a time series meteorology file in which meteorology data was input for specific time periods at one measured height. The model computes meteorological data for all other pertinent heights based on the meteorological input data and on the atmospheric stability category known as the Pasquill category [1]. VLSTRACK is programmed to either allow the program to specify the Pasquill stability category based on the meteorological conditions, time of day, and terrain information or to allow the operator to select a particular stability category. There are seven categories available, ranging from very unstable to very stable. In this case, the option was selected for the program to determine the Pasquill category.

A height-time variable meteorology file was used for all MMD comparative analysis runs in order to fix the wind at a constant 0 km/hr and the temperature at a constant 21 ° C at all elevations

to parallel the conditions of the fluid dynamics calculations [2]. It was necessary to use the 0.001-km/hr wind speed because an anomaly of the model did not allow a constant 0 km/hr wind speed. The height-time variable meteorology file includes ground surface type, Pasquill stability category, cloud cover, terrain elevation above sea level, threat measurement height above sea level, wind bearing, wind speed, air temperature, and atmospheric pressure. The height-time variable meteorology file that was used consisted of two identical time steps. Including the constant temperature and wind, the additional parameters were brush-type ground surface, neutral Pasquill stability category, clear—no cloud cover, and 0-m terrain elevation above sea level for location to look at the deposition. Four records were included for each time period. They were as follows:

- 0.001-km measurement height above sea level, 90° true north (DTN) [1] wind bearing, 0.001-km/hr wind speed, 21° C air temperature at 1,000-mbar atmospheric pressure.

- 0.5-km measurement height above sea level, 90 DTN wind bearing, 0.001-km/hr wind speed, 21° C air temperature at 950-mbar atmospheric pressure.

- 1.0-km measurement height above sea level, 90 DTN wind bearing, 0.001-km/hr wind speed, 21° C air temperature at 900-mbar atmospheric pressure.

- 2.0-km measurement height above sea level, 90 DTN wind bearing, 0.001-km/hr wind speed, 21° C air temperature at 800-mbar atmospheric pressure.

After the water agent, puff munitions, and meteorological data were detailed in the appropriate parameter files, the next step was to complete an attack scenario using the six available VLSTRACK editor windows. Included is the time of day for onset of the attack—in this case, release of the first puff. All of the modeling scenarios were performed using 0400 (military denoted) local onset time since night time and early morning conditions provide the calmest atmospheric conditions [4]. Cumulative deposition intervals of 1 min were used for run output. Level of detail of deposition contour levels was set as low as possible—0.01 mg/m^2 in order to detect any deposition.

4. Example Application: Number Crunching of Terminal Velocity

Model scenarios were built and run one at a time, with each subsequent run description contingent on the preceding run results. Output graphics of hazard footprints were viewed at each interval during each model run to monitor the time at which water deposited on the ground. Model scenario inputs were modified until run output graphics exhibited deposition. A uniform base scenario was then defined and run sequentially varying only sphere MMDs from 500 μ to 6,000 μ. Terminal velocity numbers were calculated by looking at each individual munition puff and by analyzing all resulting output files. In particular, after viewing deposition contours in the graphics output display file, the corresponding VLSTRACK.TRK output file was saved for each file. This VLSTRACK.TRK file shows tracking for each droplet (discharged in the munition puff), including such data as the x and y distance traveled and the height of the droplet at that record. The terminal velocity was approximated by looking at the time it took for deposition to start and the height the droplets were released as recorded in the output file VLSTRACK.OUT file [1]. The VLSTRACK.TRK file was also used to calculate an exact terminal velocity by calculating the difference in the height of the droplet from one time snapshot to the next.

5. Conclusions and Results

The VLSTRACK.TRK, Table 2, and the VLSTRACK.REC, Table 3, output files track and record the cloud properties of all airborne vapor, droplet, or particle clouds for each individual puff released. These files were used to calculate and compare the terminal velocities of water beads from each puff. The resulting terminal velocity calculations from tracked puffs were all consistent for each individual MMD.

The results of the VLSTRACK calculated terminal velocities were within expected tolerance of the fluid dynamics calculations up to a MMD of 2,500 μ. Table 1 shows the VLSTRACK and fluid

dynamics [2] calculated terminal velocity of a rigid sphere of water and the measured terminal velocity of rain droplets.

The fluid dynamics calculations are consistent with the measured terminal velocities of up to 5,000 μ MMD, while VLSTRACK calculations are consistent to water droplets of up to 2,500 μ MMD. In fact this conclusion can also be obtained through statistical analysis which compares calculated values with each other and with experiments [5].

6. Discussion of the Significant Results

The final results of this study showed that VLSTRACK models terminal velocity accurately for rigid spheres of water with MMDs from 500 to 2,500 μ as indicated by the heavy line in Table 1. The larger the MMD, >2,500 μ, the more discrepancy in the results. These results are reassuring and could be expected since chemical agents that VLSTRACK is intended to model would not have such large MMDs anyway. For example, typical MMDs for most dusty and bio agents are only 5 μ, for glass beads are 250 μ, for neat agent droplets are 500 μ, and for thickened agent droplets are 2,500 μ maximum. VLSTRACK terminal velocity calculations also remained uniform for each different MMD even when altering mass or release position. The discrepancy of the fluid dynamics calculations to the measured terminal velocities beyond 5,000 μ MMD would indicate a breakup of droplets.

This comparison study clearly indicates the validity of VLSTRACK for evaluating terminal velocities in the range for which it is intended.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
0	1	1	0.0	0.0	1200.0	0.0	0.0	0.0	0.0	0.0	800.0	0.0	500.0	6.3494E+11	1.0000E+07
0	1	2	10.0	0.0	1200.0	0.0	0.0	0.0	0.0	0.0	800.0	0.0	500.0	6.3494E+11	1.0000E+07
60	1	1	-0.4	-5.2	967.2	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	2	9.3	-5.6	971.1	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	3	19.1	-6.1	974.9	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	4	28.9	-6.5	978.8	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	5	38.7	-6.9	982.7	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	6	48.5	-7.4	986.6	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	7	58.3	-7.8	990.5	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	8	68.1	-8.3	994.3	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	9	77.9	-8.7	998.2	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	10	87.6	-9.2	1002.1	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	7.6418E+07	1.0000E+07
60	1	11	97.4	-9.6	1006.0	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	12	107.3	-9.1	1009.9	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	13	117.1	-8.7	1013.7	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	14	126.9	-8.2	1017.6	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
60	1	15	136.8	-7.8	1021.5	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	16	146.6	-7.3	1025.4	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	17	156.4	-6.8	1029.3	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	18	166.2	-6.4	1033.1	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	19	176.1	-5.9	1037.0	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	20	185.9	-5.5	1040.9	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.0038E+08	1.0000E+07
60	1	21	195.7	-5.0	1044.8	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	22	205.7	-4.5	1048.7	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	23	215.7	-4.0	1052.5	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	24	225.8	-3.5	1056.4	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	25	235.8	-3.0	1060.3	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	26	245.8	-2.6	1064.2	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	27	255.8	-2.1	1068.1	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	28	265.8	-1.6	1071.9	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	29	275.8	-1.1	1075.8	0.2	0.2	0.2	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
60	1	30	285.8	-0.6	1079.7	0.2	0.2	0.0	0.0	0.0	800.0	0.0	500.0	1.4013E+08	1.0000E+07
120	1	1	3.7	-0.2	734.4	0.9	0.9	0.7	0.0	0.0	800.0	0.0	500.0	1.1803E+06	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
120	1	2	13.5	-0.6	738.2	0.9	0.9	0.7	0.0	0.0	800.0	0.0	500.0	1.2060E+06	1.0000E+07
120	1	3	23.2	-1.0	742.1	0.7	0.7	0.5	0.0	0.0	800.0	0.0	500.0	2.6422E+06	1.0000E+07
120	1	4	33.0	-1.5	746.0	0.7	0.7	0.5	0.0	0.0	800.0	0.0	500.0	2.6922E+06	1.0000E+07
120	1	5	42.8	-1.9	749.9	0.7	0.7	0.5	0.0	0.0	800.0	0.0	500.0	2.7434E+06	1.0000E+07
120	1	6	52.6	-2.4	753.8	0.7	0.7	0.5	0.0	0.0	800.0	0.0	500.0	2.7961E+06	1.0000E+07
120	1	7	62.4	-2.8	757.6	0.6	0.6	0.5	0.0	0.0	800.0	0.0	500.0	2.8502E+06	1.0000E+07
120	1	8	72.2	-3.2	761.5	0.6	0.6	0.5	0.0	0.0	800.0	0.0	500.0	2.9058E+06	1.0000E+07
120	1	9	82.0	-3.7	765.4	0.6	0.6	0.5	0.0	0.0	800.0	0.0	500.0	2.9629E+06	1.0000E+07
120	1	10	91.8	-4.1	769.3	0.6	0.6	0.5	0.0	0.0	800.0	0.0	500.0	3.0216E+06	1.0000E+07
120	1	11	101.5	-4.6	773.2	0.6	0.6	0.5	0.0	0.0	800.0	0.0	500.0	3.1761E+06	1.0000E+07
120	1	12	111.4	-4.1	777.0	0.6	0.6	0.5	0.0	0.0	800.0	0.0	500.0	3.2413E+06	1.0000E+07
120	1	13	121.2	-3.7	780.9	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	14	131.0	-3.2	784.8	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	15	140.9	-2.7	788.7	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	16	150.7	-2.3	792.6	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	17	160.5	-1.8	796.4	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	18	170.3	-1.4	800.3	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.2632E+07	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
120	1	19	180.2	-0.9	804.2	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	20	190.0	-0.4	808.1	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.0836E+07	1.0000E+07
120	1	21	199.8	0.0	812.0	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	22	209.8	0.5	815.8	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	23	219.9	1.0	819.7	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	24	229.9	1.5	823.6	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	25	239.9	2.0	827.5	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	26	249.9	2.5	831.4	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	27	259.9	3.0	835.2	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	28	269.9	3.4	839.1	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	29	279.9	3.9	843.0	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
120	1	30	289.9	4.4	846.9	0.3	0.3	0.3	0.0	0.0	800.0	0.0	500.0	3.5568E+07	1.0000E+07
180	1	1	4.6	-4.6	501.5	2.1	2.1	1.6	0.0	0.0	800.0	0.0	500.0	8.9118E+04	1.0000E+07
180	1	2	14.3	-5.0	505.4	2.1	2.1	1.6	0.0	0.0	800.0	0.0	500.0	9.0633E+04	1.0000E+07
180	1	3	24.1	-5.5	509.3	2.0	2.0	1.5	0.0	0.0	800.0	0.0	500.0	1.0291E+05	1.0000E+07
180	1	4	33.9	-5.9	513.2	2.0	2.0	1.5	0.0	0.0	800.0	0.0	500.0	1.0461E+05	1.0000E+07
180	1	5	43.7	-6.3	517.1	2.0	2.0	1.5	0.0	0.0	800.0	0.0	500.0	1.0635E+05	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
180	1	6	53.5	-6.8	520.9	2.0	2.0	1.5	0.0	0.0	800.0	0.0	500.0	1.0814E+05	1.0000E+07
180	1	7	63.3	-7.2	524.8	2.0	2.0	1.5	0.0	0.0	800.0	0.0	500.0	1.0997E+05	1.0000E+07
180	1	8	73.1	-7.7	528.7	2.0	2.0	1.5	0.0	0.0	800.0	0.0	500.0	1.1185E+05	1.0000E+07
180	1	9	82.9	-8.1	532.6	1.9	1.9	1.5	0.0	0.0	800.0	0.0	500.0	1.1378E+05	1.0000E+07
180	1	10	92.6	-8.5	536.5	1.9	1.9	1.5	0.0	0.0	800.0	0.0	500.0	1.1576E+05	1.0000E+07
180	1	11	102.4	-9.0	540.3	1.9	1.9	1.5	0.0	0.0	800.0	0.0	500.0	1.1819E+05	1.0000E+07
180	1	12	112.3	-8.5	544.2	1.9	1.9	1.5	0.0	0.0	800.0	0.0	500.0	1.2028E+05	1.0000E+07
180	1	13	122.1	-8.1	548.1	1.8	1.8	1.4	0.0	0.0	800.0	0.0	500.0	1.3998E+05	1.0000E+07
180	1	14	131.9	-7.6	552.0	1.8	1.8	1.4	0.0	0.0	800.0	0.0	500.0	1.4239E+05	1.0000E+07
180	1	15	141.8	-7.2	555.9	1.8	1.8	1.4	0.0	0.0	800.0	0.0	500.0	1.4485E+05	1.0000E+07
180	1	16	151.6	-6.7	559.7	1.8	1.8	1.4	0.0	0.0	800.0	0.0	500.0	1.4738E+05	1.0000E+07
180	1	17	161.4	-6.2	563.6	1.8	1.8	1.4	0.0	0.0	800.0	0.0	500.0	1.4998E+05	1.0000E+07
180	1	18	171.2	-5.8	567.5	1.8	1.8	1.4	0.0	0.0	800.0	0.0	500.0	1.5264E+05	1.0000E+07
180	1	19	181.1	-5.3	571.4	1.7	1.7	1.3	0.0	0.0	800.0	0.0	500.0	1.6029E+05	1.0000E+07
180	1	20	190.9	-4.9	575.3	1.7	1.7	1.3	0.0	0.0	800.0	0.0	500.0	1.6316E+05	1.0000E+07
180	1	21	200.7	-4.4	579.1	1.7	1.7	1.3	0.0	0.0	800.0	0.0	500.0	1.7237E+05	1.0000E+07
180	1	22	210.7	-3.9	583.0	1.7	1.7	1.3	0.0	0.0	800.0	0.0	500.0	1.7549E+05	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
180	1	23	220.7	-3.4	586.9	1.6	1.6	1.3	0.0	0.0	800.0	0.0	500.0	1.8492E+05	1.0000E+07
180	1	24	230.8	-2.9	590.8	1.6	1.6	1.3	0.0	0.0	800.0	0.0	500.0	1.8830E+05	1.0000E+07
180	1	25	240.8	-2.4	594.7	1.6	1.6	1.2	0.0	0.0	800.0	0.0	500.0	1.9877E+05	1.0000E+07
180	1	26	250.8	-1.9	598.6	1.6	1.6	1.2	0.0	0.0	800.0	0.0	500.0	2.0243E+05	1.0000E+07
180	1	27	260.8	-1.5	602.4	1.6	1.6	1.2	0.0	0.0	800.0	0.0	500.0	2.1410E+05	1.0000E+07
180	1	28	270.8	-1.0	606.3	1.6	1.6	1.2	0.0	0.0	800.0	0.0	500.0	2.1807E+05	1.0000E+07
180	1	29	280.8	-0.5	610.2	1.5	1.5	1.2	0.0	0.0	800.0	0.0	500.0	2.3114E+05	1.0000E+07
180	1	30	290.8	0.0	614.1	1.5	1.5	1.2	0.0	0.0	800.0	0.0	500.0	2.3545E+05	1.0000E+07
240	1	1	6.5	-7.9	268.7	3.3	3.3	2.4	0.0	0.0	800.0	0.0	500.0	2.4376E+04	1.0000E+07
240	1	2	16.3	-8.4	272.6	3.3	3.3	2.4	0.0	0.0	800.0	0.0	500.0	2.4697E+04	1.0000E+07
240	1	3	26.1	-8.8	276.5	3.2	3.2	2.4	0.0	0.0	800.0	0.0	500.0	2.6182E+04	1.0000E+07
240	1	4	35.8	-9.2	280.4	3.2	3.2	2.3	0.0	0.0	800.0	0.0	500.0	2.6521E+04	1.0000E+07
240	1	5	45.6	-9.7	284.2	3.2	3.2	2.3	0.0	0.0	800.0	0.0	500.0	2.6866E+04	1.0000E+07
240	1	6	55.4	-10.1	288.1	3.2	3.2	2.3	0.0	0.0	800.0	0.0	500.0	2.7219E+04	1.0000E+07
240	1	7	65.2	-10.6	292.0	3.2	3.2	2.3	0.0	0.0	800.0	0.0	500.0	2.7578E+04	1.0000E+07
240	1	8	75.0	-11.0	295.9	3.1	3.1	2.3	0.0	0.0	800.0	0.0	500.0	2.7945E+04	1.0000E+07
240	1	9	84.8	-11.5	299.8	3.1	3.1	2.3	0.0	0.0	800.0	0.0	500.0	2.8319E+04	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
240	1	10	94.6	-11.9	303.6	3.1	3.1	2.3	0.0	0.0	800.0	0.0	500.0	2.8701E+04	1.0000E+07
240	1	11	104.4	-12.3	307.5	3.1	3.1	2.3	0.0	0.0	800.0	0.0	500.0	2.9131E+04	1.0000E+07
240	1	12	114.2	-11.9	311.4	3.1	3.1	2.3	0.0	0.0	800.0	0.0	500.0	2.9529E+04	1.0000E+07
240	1	13	124.0	-11.4	315.3	3.0	3.0	2.2	0.0	0.0	800.0	0.0	500.0	3.1504E+04	1.0000E+07
240	1	14	133.9	-11.0	319.2	3.0	3.0	2.2	0.0	0.0	800.0	0.0	500.0	3.1927E+04	1.0000E+07
240	1	15	143.7	-10.5	323.0	3.0	3.0	2.2	0.0	0.0	800.0	0.0	500.0	3.2359E+04	1.0000E+07
240	1	16	153.5	-10.0	326.9	3.0	3.0	2.2	0.0	0.0	800.0	0.0	500.0	3.2800E+04	1.0000E+07
240	1	17	163.3	-9.6	330.8	3.0	3.0	2.2	0.0	0.0	800.0	0.0	500.0	3.3250E+04	1.0000E+07
240	1	18	173.2	-9.1	334.7	2.9	2.9	2.2	0.0	0.0	800.0	0.0	500.0	3.3709E+04	1.0000E+07
240	1	19	183.0	-8.7	338.6	2.9	2.9	2.2	0.0	0.0	800.0	0.0	500.0	3.4566E+04	1.0000E+07
240	1	20	192.8	-8.2	342.4	2.9	2.9	2.2	0.0	0.0	800.0	0.0	500.0	3.5048E+04	1.0000E+07
240	1	21	202.7	-7.7	346.3	2.9	2.9	2.1	0.0	0.0	800.0	0.0	500.0	3.6010E+04	1.0000E+07
240	1	22	212.7	-7.3	350.2	2.9	2.9	2.1	0.0	0.0	800.0	0.0	500.0	3.6517E+04	1.0000E+07
240	1	23	222.7	-6.8	354.1	2.8	2.8	2.1	0.0	0.0	800.0	0.0	500.0	3.7477E+04	1.0000E+07
240	1	24	232.7	-6.3	358.0	2.8	2.8	2.1	0.0	0.0	800.0	0.0	500.0	3.8008E+04	1.0000E+07
240	1	25	242.7	-5.8	361.9	2.8	2.8	2.1	0.0	0.0	800.0	0.0	500.0	3.9026E+04	1.0000E+07
240	1	26	252.7	-5.3	365.7	2.8	2.8	2.1	0.0	0.0	800.0	0.0	500.0	3.9583E+04	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
240	1	27	262.7	-4.8	369.6	2.8	2.8	2.1	0.0	0.0	800.0	0.0	500.0	4.0661E+04	1.0000E+07
240	1	28	272.7	-4.3	373.5	2.7	2.7	2.0	0.0	0.0	800.0	0.0	500.0	4.1246E+04	1.0000E+07
240	1	29	282.7	-3.8	377.4	2.7	2.7	2.0	0.0	0.0	800.0	0.0	500.0	4.2389E+04	1.0000E+07
240	1	30	292.7	-3.3	381.3	2.7	2.7	2.0	0.0	0.0	800.0	0.0	500.0	4.3005E+04	1.0000E+07
300	1	1	12.3	-5.7	35.9	4.5	4.5	3.2	0.0	0.0	800.0	0.0	500.0	9.9342E+03	1.0000E+07
300	1	2	22.1	-6.1	39.8	4.5	4.5	3.2	0.0	0.0	800.0	0.0	500.0	1.0039E+04	1.0000E+07
300	1	3	31.8	-6.6	43.7	4.4	4.4	3.1	0.0	0.0	800.0	0.0	500.0	1.0399E+04	1.0000E+07
300	1	4	41.6	-7.0	47.5	4.4	4.4	3.1	0.0	0.0	800.0	0.0	500.0	1.0507E+04	1.0000E+07
300	1	5	51.4	-7.4	51.4	4.4	4.4	3.1	0.0	0.0	800.0	0.0	500.0	1.0617E+04	1.0000E+07
300	1	6	61.2	-7.9	55.3	4.4	4.4	3.1	0.0	0.0	800.0	0.0	500.0	1.0728E+04	1.0000E+07
300	1	7	71.0	-8.3	59.2	4.4	4.4	3.1	0.0	0.0	800.0	0.0	500.0	1.0842E+04	1.0000E+07
300	1	8	80.8	-8.8	63.1	4.3	4.3	3.1	0.0	0.0	800.0	0.0	500.0	1.0957E+04	1.0000E+07
300	1	9	90.6	-9.2	66.9	4.3	4.3	3.1	0.0	0.0	800.0	0.0	500.0	1.1075E+04	1.0000E+07
300	1	10	100.4	-9.7	70.8	4.3	4.3	3.1	0.0	0.0	800.0	0.0	500.0	1.1194E+04	1.0000E+07
300	1	11	110.2	-10.1	74.7	4.3	4.3	3.1	0.0	0.0	800.0	0.0	500.0	1.1324E+04	1.0000E+07
300	1	12	120.0	-9.6	78.6	4.3	4.3	3.0	0.0	0.0	800.0	0.0	500.0	1.1447E+04	1.0000E+07
300	1	13	129.8	-9.2	82.5	4.2	4.2	3.0	0.0	0.0	800.0	0.0	500.0	1.1889E+04	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 2. Example of the VLSTRACK.TRK Output File Containing the Properties of the Droplets as They Propagate Through the Atmosphere (continued)

time	idrop	in	x-dist.	y-dist.	height	sigma_x	sigma_y	sigma_z	shavg	shght	mix. ht.	Cld. rot.	radius	conc.	mass
300	1	14	139.6	-8.7	86.3	4.2	4.2	3.0	0.0	0.0	800.0	0.0	500.0	1.2016E+04	1.0000E+07
300	1	15	149.5	-8.3	90.2	4.2	4.2	3.0	0.0	0.0	800.0	0.0	500.0	1.2146E+04	1.0000E+07
300	1	16	159.3	-7.8	94.1	4.2	4.2	3.0	0.0	0.0	800.0	0.0	500.0	1.2279E+04	1.0000E+07
300	1	17	169.1	-7.3	98.0	4.2	4.2	3.0	0.0	0.0	800.0	0.0	500.0	1.2413E+04	1.0000E+07
300	1	18	179.0	-6.9	101.9	4.1	4.1	3.0	0.0	0.0	800.0	0.0	500.0	1.2550E+04	1.0000E+07
300	1	19	188.8	-6.4	105.7	4.1	4.1	2.9	0.0	0.0	800.0	0.0	500.0	1.2763E+04	1.0000E+07
300	1	20	198.6	-6.0	109.6	4.1	4.1	2.9	0.0	0.0	800.0	0.0	500.0	1.2905E+04	1.0000E+07
300	1	21	208.4	-5.5	113.5	4.1	4.1	2.9	0.0	0.0	800.0	0.0	500.0	1.3137E+04	1.0000E+07
300	1	22	218.5	-5.0	117.4	4.1	4.1	2.9	0.0	0.0	800.0	0.0	500.0	1.3284E+04	1.0000E+07
300	1	23	228.5	-4.5	121.3	4.0	4.0	2.9	0.0	0.0	800.0	0.0	500.0	1.3515E+04	1.0000E+07
300	1	24	238.5	-4.0	125.2	4.0	4.0	2.9	0.0	0.0	800.0	0.0	500.0	1.3668E+04	1.0000E+07
300	1	25	248.5	-3.5	129.0	4.0	4.0	2.9	0.0	0.0	800.0	0.0	500.0	1.3908E+04	1.0000E+07
300	1	26	258.5	-3.1	132.9	4.0	4.0	2.9	0.0	0.0	800.0	0.0	500.0	1.4066E+04	1.0000E+07
300	1	27	268.5	-2.6	136.8	4.0	4.0	2.8	0.0	0.0	800.0	0.0	500.0	1.4316E+04	1.0000E+07
300	1	28	278.5	-2.1	140.7	3.9	3.9	2.8	0.0	0.0	800.0	0.0	500.0	1.4480E+04	1.0000E+07
300	1	29	288.5	-1.6	144.6	3.9	3.9	2.8	0.0	0.0	800.0	0.0	500.0	1.4741E+04	1.0000E+07
300	1	30	298.5	-1.1	148.4	3.9	3.9	2.8	0.0	0.0	800.0	0.0	500.0	1.4910E+04	1.0000E+07

Note: The columns are for time in seconds, droplet size group number, puff number, downwind distance in meters, crosswind distance in meters, height above sea level in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, vertical cloud sigma in meters, average terrain elevation in meters, local terrain elevation in meters, mixing layer height in meters, downwind cloud rotation angle in degrees, droplet radius in microns, cloud concentration in milligrams per cubic meter, and cloud mass in milligrams, respectively.

Table 3. Example of the VLSTRACK.REC Output File Containing the Properties of the Droplets Impacting the Ground Surface

ismth	idrop	in	time	diameter	x-distance	y-distance	sigma_x	sigma_y	cloud rot.	conc.
0	1	1	309.3	1000.0	12.3	−4.5	4.7	4.7	0.0	7.2476E+04
0	1	2	310.3	1000.0	21.7	−4.8	4.8	4.8	0.0	6.9953E+04
0	1	3	311.3	1000.0	31.6	−4.7	4.7	4.7	0.0	7.1410E+04
0	1	4	312.3	1000.0	41.4	−4.7	4.7	4.7	0.0	7.1915E+04
0	1	5	313.3	1000.0	51.3	−4.7	4.7	4.7	0.0	7.2426E+04
0	1	6	314.3	1000.0	61.1	−4.6	4.7	4.7	0.0	7.2943E+04
0	1	7	315.3	1000.0	71.0	−4.6	4.8	4.8	0.0	7.0379E+04
0	1	8	316.3	1000.0	80.7	−4.5	4.7	4.7	0.0	7.0879E+04
0	1	9	317.3	1000.0	90.4	−4.5	4.7	4.7	0.0	7.1385E+04
0	1	10	318.3	1000.0	100.1	−4.4	4.7	4.7	0.0	7.1898E+04
0	1	11	319.3	1000.0	109.8	−4.4	4.7	4.7	0.0	7.2439E+04
0	1	12	320.3	1000.0	119.5	−3.7	4.8	4.8	0.0	6.9918E+04
0	1	13	321.3	1000.0	129.0	−3.5	4.7	4.7	0.0	7.1374E+04
0	1	14	322.3	1000.0	138.5	−3.4	4.7	4.7	0.0	7.1878E+04
0	1	15	323.3	1000.0	148.0	−3.3	4.7	4.7	0.0	7.2389E+04
0	1	16	324.3	1000.0	157.5	−3.2	4.7	4.7	0.0	7.2905E+04
0	1	17	325.3	1000.0	167.0	−2.9	4.8	4.8	0.0	7.0344E+04

Note: The columns are for cloud smoothing index, droplet size group number, puff number, time in seconds, droplet diameter in microns, downwind distance in meters, crosswind distance in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, downwind cloud rotation angle in degrees, and concentration in milligrams per cubic meter, respectively.

Table 3. Example of the VLSTRACK.REC Output File Containing the Properties of the Droplets Impacting the Ground Surface (continued)

ismth	idrop	in	time	diameter	x-distance	y-distance	sigma_x	sigma_y	cloud rot.	conc.
0	1	18	326.3	1000.0	176.7	−2.0	4.7	4.7	0.0	7.0843E+04
0	1	19	327.3	1000.0	186.4	−1.0	4.7	4.7	0.0	7.1547E+04
0	1	20	328.3	1000.0	196.1	−0.1	4.7	4.7	0.0	7.2058E+04
0	1	21	329.3	1000.0	205.8	0.8	4.7	4.7	0.0	7.2804E+04
0	1	22	330.3	1000.0	215.7	1.8	4.9	4.9	0.0	6.7337E+04
0	1	23	331.3	1000.0	225.6	2.8	4.8	4.8	0.0	6.7987E+04
0	1	24	332.3	1000.0	235.6	3.7	4.8	4.8	0.0	6.8464E+04
0	1	25	333.3	1000.0	245.5	4.7	4.8	4.8	0.0	6.9132E+04
0	1	26	334.3	1000.0	255.5	5.7	4.8	4.8	0.0	6.9620E+04
0	1	27	335.3	1000.0	265.4	6.7	4.8	4.8	0.0	7.0305E+04
0	1	28	336.3	1000.0	275.4	7.6	4.7	4.7	0.0	7.0804E+04
0	1	29	337.3	1000.0	285.3	8.6	4.7	4.7	0.0	7.1508E+04
0	1	30	338.3	1000.0	295.3	9.6	4.7	4.7	0.0	7.2019E+04

Note: The columns are for cloud smoothing index, droplet size group number, puff number, time in seconds, droplet diameter in microns, downwind distance in meters, crosswind distance in meters, downwind cloud sigma in meters, crosswind cloud sigma in meters, downwind cloud rotation angle in degrees, and concentration in milligrams per cubic meter, respectively.

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REPORT DOCUMENTATION PAGE

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1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 1999	Final, Aug 97 - Apr 98

4. TITLE AND SUBTITLE
Correlation Analysis of VLSTRACK Model Results With Theoretical and Experimental Data for Rigid Sphere Terminal Velocities

5. FUNDING NUMBERS
6605604D671

6. AUTHOR(S)
Josip Z. Soln and Judith T. McCullen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: AMSRL-SL-BN
Aberdeen Proving Ground (EA), MD 21010-5423

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TR-1938

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

10.SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
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12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

In this report, we undertake the task of verifying the VLSTRACK model on the specific example of raindrop terminal velocities, which were calculated directly from Fluid Dynamics. In this example, the verification is in good agreement with experiments.

14. SUBJECT TERMS
VLSTRACK, fluid dynamics, terminal velocity

15. NUMBER OF PAGES
29

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
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NSN 7540-01-280-5500

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